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Chapter 20. Urban Stormwater Runoff Management

Urban stormwater runoff management is a broad series of activities to manage both stormwater and dry-weather runoff. Dry-weather runoff occurs when, for example, excess landscape irrigation water flows to the storm drain. Traditionally, urban stormwater runoff management was viewed as a response to flood control concerns resulting from the effects of urbanization. Concerns about the water quality impacts of urban runoff have led water agencies to look at watershed approaches to control runoff and provide other benefits (see Box 20-1, “Objectives of Urban Stormwater Runoff Management”). As a result, urban stormwater runoff management is now linked to other resource management strategies, including pollution prevention (covered in Chapter 18 of this volume), land use planning and management (Chapter 24), watershed management (Chapter 27), urban water use efficiency (Chapter 3), municipal recycled water (Chapter 12), recharge area protection (Chapter 25), and conjunctive management and groundwater (Chapter 9).

PLACEHOLDER Box 20-1 Objectives of Urban Stormwater Runoff Management

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of this chapter.]

Urban Stormwater Runoff Management in California

The traditional approach to runoff management views urban runoff as a flood management problem in which water needs to be conveyed as quickly as possible from urban areas to waterways in order to protect public safety and property. Consequently, precipitation-induced runoff in urban areas has been viewed as waste, and not a resource.

Urbanization alters flow pathways, water storage, pollutant levels, rates of evaporation, groundwater recharge, surface runoff, the timing and extent of flooding, the sediment yield of rivers, and the suitability and viability of aquatic habitats. The traditional approach to managing urban and stormwater runoff has generally been successful at preventing flood damage, but it has several disadvantages. In order to convey water quickly, natural waterways are often straightened and lined with concrete, resulting in a loss of habitat and impacts on natural stream physical and biological processes. Urbanization creates impervious surfaces, meaning stormwater does not infiltrate into subsurface aquifers. These impervious surfaces collect pollutants that are washed off to surface waters when it rains. The impervious surfaces also increase runoff volumes and velocities, resulting in streambank erosion, and potential flooding problems downstream. Because of the emphasis on removing the water quickly, the opportunity to use storm-generated runoff for multiple benefits is reduced.

A watershed approach for urban stormwater runoff management tries to emulate and preserve the natural hydrologic cycle that is altered by urbanization. The watershed approach consists of a series of best management practices (BMPs) designed to reduce the pollutant loading and reduce the volumes and velocities of urban runoff discharged to surface waters. These BMPs may include facilities to capture, treat, and recharge groundwater with urban runoff; public education campaigns to inform the public about

stormwater pollution, including the proper use and disposal of household chemicals; and technical assistance and stormwater pollution prevention training.

Methods for recharging groundwater with urban runoff include having roof runoff drain to vegetated areas; draining runoff from parking lots, driveways, and walkways into landscaped areas with permeable soils; using dry wells and permeable surfaces; and collecting and routing stormwater runoff to basins. Infiltration may require the use of source control and pretreatment before infiltration. Infiltration enables the soil to naturally filter many of the pollutants found in runoff and reduces the volume and pollutant load of the runoff that is discharged to surface waters. An example is the Elmer Avenue Neighborhood Retrofit Demonstration Project (see Box 20-2). The watershed approach will not prevent, nor should it prevent, all urban runoff from entering waterways. Elements of the traditional conveyance and storage strategy are still needed in order to protect downstream beneficial uses, protect water right holders, and protect the public from floods. In addition to infiltration of stormwater, other BMPs include the use of rain barrels and cisterns to “harvest” stormwater for later use (e.g., irrigation), and the use of structural controls that are designed to capture stormwater runoff and slowly release it into streams in order to mimic the natural hydrograph that existed before development occurred. In Los Angeles, the nonprofit TreePeople organization constructed a 216,000-gallon cistern in Coldwater Canyon Park to collect and store stormwater from building rooftops and parking lots for irrigation use during the dry months (see Box 20-3).

PLACEHOLDER Box 20-2 Elmer Avenue Neighborhood Retrofit Demonstration Project

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of this chapter.]

PLACEHOLDER Box 20-3 Stormwater Cistern, Coldwater Canyon Park, Los Angeles

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Urban stormwater runoff management has become more important and more controversial over the last two decades as municipal governments have been held increasingly responsible for pollutants washed from developed and developing areas within their jurisdictions into the storm sewer system and discharged into waterways. Unlike pollution from industrial and sewage treatment plants, pollutants in urban runoff and stormwater runoff come from many diffuse sources (see Box 20-4) and typically are not treated prior to being discharged to surface waters. As rainfall or snowmelt moves over the urban landscape, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and, potentially, groundwater. Pollution associated with discharges from a storm sewer system can occur outside of storms also, from landscape irrigation flows, improper disposal of trash or yard waste, illegal dumping, and leaky septic systems.

PLACEHOLDER Box 20-4 Examples of Pollution in the Urban Environment

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of this chapter.]

Runoff in the urban environment, both storm-generated and dry weather flows, has been shown to be a significant source of pollutants to the surface waters of the nation. As a result, the 1987 amendments to the federal Clean Water Act (CWA) required that discharges from municipal separate storm sewer

systems serving a population of 100,000 or more must be in compliance with requirements contained in National Pollutant Discharge Elimination System (NPDES) permits. The U.S. Environmental Protection Agency (EPA) promulgated regulations for these discharges in 1990. These regulations were subsequently amended in 1999 to require that municipal separate storm sewer systems that served populations fewer than 100,000 and were located in an urbanized area were subject to requirements contained in an NPDES permit. In California, the authority to regulate urban and stormwater runoff under the NPDES system has been delegated by EPA to the State Water Resources Control Board (SWRCB) and the nine regional water quality control boards (RWQCBs).

Under the initial NPDES permits issued in the 1990s, municipalities were required to develop and implement a plan to reduce the discharge of pollutants into waterways, including the discharges from areas of new development and significant redevelopment. For the new development and redevelopment projects, the permit requirements were generally met by implementing BMPs that addressed discharges taking place during the construction activity but did not address discharges occurring after construction was completed (post-construction controls). Since the first municipal stormwater permits were adopted, and with continued beach closures and other pollution problems associated with urban runoff, it has become clear that post-construction controls, retrofit, and more advanced measures will be required in some areas to comply with water quality regulations (see Box 20-5).

PLACEHOLDER Box 20-5 Implementation Plan for Urban Stormwater Runoff Management Programs

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of this chapter.]

The SWRCB and RWQCBs seek opportunities for managing urban runoff that will result in multiple benefits. Low-impact development (LID) is one such collection of management techniques that has multiple benefits. LID is a sustainable practice that benefits water supply and contributes to water quality protection. Unlike traditional stormwater management, which collects and conveys stormwater runoff through storm drains, pipes, or other conveyances to a centralized stormwater facility, LID takes a different approach by using site design and stormwater management to maintain the site's predevelopment runoff rates and volumes. The goal of LID is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to the source of rainfall. LID has been a proven approach in other parts of the country and is seen in California as an alternative to conventional stormwater management. The SWRCB and RWQCBs are advancing LID in California in various ways.

LID can be used to benefit water quality, address the modifications to the hydrologic cycle, and be a means to augment local water supply through either infiltration or water harvesting. In light of this, the SWRCB and RWQCBs are incorporating the principals of LID into the permits now being issued and are funding projects that highlight LID using the various voter-approved bond funds.

The SWRCB and RWQCBs are also required under the federal CWA Section 303(d) and federal regulations (Code of Federal Regulations [CFR] Title 40, Section 130) to prepare a list of water bodies requiring total maximum daily loads (TMDLs) because they do not meet water quality standards and set priorities for these water bodies. The Section 303(d) list was last revised in 2010 and is currently being updated for 2012. Federal regulations require the Section 303(d) list to be updated every two years. TMDLs represent the total pollutant load a water body can assimilate before the water body's beneficial

uses are considered to be impaired and water quality standards are no longer met. Through the process of establishing the Section 303(d) list of impaired water bodies, it has often been found that urban runoff is a source of pollutants contributing to the impairment.

NPDES permits now issued to local agencies for discharges of stormwater require the implementation of specific measures to reduce the amount of pollutants in urban runoff. Permits for discharge to listed water bodies having a TMDL must be consistent with the waste load allocations in a TMDL. Under California law, TMDLs include implementation plans for meeting water quality standards. The implementation plans allow for time to implement control strategies to meet water quality standards.

Potential Benefits

The primary benefits of urban stormwater runoff management are to reduce surface water pollution and improve flood protection. Additional benefits may be to increase water supply through groundwater recharge in areas with suitable soil and geological conditions, and where pollution prevention programs are in place to minimize the impact on groundwater. Groundwater recharge and stormwater retention sites can also be designed to provide additional benefits to wildlife habitat, parks, and open space.

Underground facilities can store runoff and release it gradually to recharge a groundwater aquifer or release it to surface waters in a manner that mimics the natural hydrologic cycle. Captured stormwater can also be used as a source of irrigation water rather than using potable water. For instance, a school campus can solve its flooding problem and develop a new sports field at the same time. These may provide secondary benefits to the local economy by creating more desirable communities. By keeping runoff on a site, storm drain systems can be downsized, which could reduce the installation and maintenance costs of such systems. A watershed planning approach to managing urban runoff allows communities to pool economic resources and obtain broader benefits to water supply, flood control, water quality, open space, and the environment.

Statewide information on the benefits of increased management of urban runoff is not available, but examples from local efforts exist. The Fresno-Clovis metropolitan area has built an extensive network of stormwater retention basins that not only recharges more than 70 percent of the annual stormwater runoff (17,000 acre-feet [af]) and removes most conventional stormwater pollutants, but also recharges excess Sierra Nevada snowmelt during the late spring and summer (27,000 af). Los Angeles County recharges an average 210,000 af of storm runoff a year, which reduces the need for expensive imported water. Agencies in the Santa Ana watershed recharge about 78,000 af of local storm runoff a year. The Los Angeles and San Gabriel Watershed Council has estimated that if 80 percent of the rainfall that falls on just a quarter of the urban area within the watershed (15 percent of the total watershed) were captured and reused, total runoff would be reduced by about 30 percent. That translates into a new supply of 132,000 af of water per year or enough to supply 800,000 people for a year.

The City of Santa Monica is an example of a municipality that is taking a watershed approach to managing urban runoff. Santa Monica's primary goal is to treat and reuse all dry-weather flows. This turns a perceived waste product into a local water resource so that beach water quality is protected and the local nonpotable water supply is augmented. However, if dry-weather discharges are necessary, the city's secondary goal is to release only treated runoff into waterways. Both goals improve water quality of the

Santa Monica Bay. The city’s goals promote development such that urbanization works with nature and the hydrologic cycle.

At the “lot” or home-owner level, LID techniques and practices can be used to reduce the amount of runoff being generated and slow its release to the storm sewer system or surface waters. Captured runoff can be harvested and stored for later use on-site. LID techniques and practices include rain barrels, cisterns, rain gardens, swales, trench drains, land grading, permeable pavers, tree-box filters, and green roofs. For further information, see Volume 3, Chapter 24, “Land Use Planning and Management.” An analysis aimed at quantifying the benefits of LID techniques was conducted by the Natural Resources Defense Council and University of California, Santa Barbara (2009), and is summarized in Box 20-6; the full report is included in Volume 4.

PLACEHOLDER Box 20-6 Efforts to Quantify Benefits of Low-Impact Development

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of this chapter.]

Increase Local Water Supplies through Stormwater Capture

[NOTE: Plan to include subsection in future draft that discusses increasing water supplies through stormwater capture and use.].

Potential Costs

Information about statewide costs to implement urban stormwater runoff management activities is not available. The SWRCB contracted with the Office of Water Programs at California State University, Sacramento, to survey six communities to estimate the costs of complying with their NPDES stormwater permits (California State University, Sacramento, 2005). Although this may address the cost for a municipality to comply with specific programmatic elements of an NPDES permit, it may not be the most applicable for looking at watershed programs seeking multiple benefits.

The City of Santa Monica illustrates the costs of managing urban runoff from the perspective of treating dry-weather flows. The city has a stormwater utility fee that generates about \$1.2 million annually and has been in place since 1995. The funds are used for various programs to reduce or treat runoff. They go to the city’s urban runoff management coordinator for the maintenance of the storm drain system and to help support other city staff that conduct runoff work. Additional funds are spent by other divisions to perform runoff management efforts, such as street sweeping, some trash collection, sidewalk cleaning, and purchasing and maintaining equipment. The city has also received five grants totaling more than \$3.5 million for the installation of structural BMP systems, all of which will require long-term maintenance and monitoring by the city. The culmination of the city’s program is the \$12 million Santa Monica Urban Runoff Recycling Facility (SMURRF), a joint project of the City of Santa Monica and the City of Los Angeles. The SMURRF project is a state-of-the-art facility that treats dry-weather runoff water before it reaches Santa Monica Bay. Up to 500,000 gallons per day of urban runoff generated in parts of the cities of Santa Monica and Los Angeles can be treated by conventional and advanced treatment systems at the SMURRF.

Major Implementation Issues

Lack of Integration with Other Resource Management Strategies

Land use planning is not conducted on a watershed basis. Many agencies spend millions of dollars annually addressing urban runoff problems with very little interagency coordination (both within the municipality and with other neighboring municipalities) even though downstream communities can be affected by activities upstream. In other words, internal communications within local government can be improved to ensure that the program goals and direction of one branch do not conflict with those of another; and local governments need to communicate with one another to ensure that land use planning on a regional level is complementary across jurisdictional boundaries.

Solutions to managing urban runoff are closely tied to many interrelated resource management strategies, including land use planning, watershed planning, water use efficiency, recycled water, protecting recharge areas, and conjunctive management. How and why water is used in the urban environment needs to be considered comprehensively within a watershed.

Climate Change

Climate change models project more frequent flood-producing storm events. These storms may overwhelm existing urban stormwater infrastructure, resulting in more localized flooding. During drought periods, additional landscape irrigation could create higher levels of runoff. In addition, contaminant buildup during extended dry conditions could result in increased impacts on coastal areas when large storms flush those contaminants out to coastal water bodies or the ocean.

Adaptation

Urban planning and development that incorporates opportunities to capture and infiltrate rainwater will assist cities in adapting to higher-precipitation storm events. Landscape design elements such as xeriscaping, drought-tolerant gardens, and bioswales can improve water capture and infiltration. Minimizing impervious areas, using regionally appropriate landscaping features, and seeking opportunities for harvesting rainwater for on-site use or infiltrating rainfall into ground water aquifers in new development will help protect against flooding from stronger storms.

Mitigation

Harvesting rainwater at the site level and infiltrating it on a regional scale can result in reducing localized flooding, as well as increasing local water supply through groundwater recharge. Harvesting when combined with the use of regionally appropriate landscaping can also reduce the amount of water needed to be delivered to the home for landscape irrigation. These activities can reduce the demand for energy-intensive water supplies, thus reducing the amount of greenhouse gas emissions produced from urban water supply.

Lack of Funding

The two main aspects of implementing urban stormwater runoff management measures are source control, including education, and structural controls. In highly urbanized areas, major costs for structural controls include purchasing land for facilities and constructing, operating, and maintaining treatment facilities. Local municipalities have limited ability to pay for retrofitting existing developed areas within

existing budgets. The provisions of Proposition 218 have limited local municipalities' ability to increase fees to pay for services required to implement robust urban stormwater runoff management programs. Additional information on Proposition 218 is available in Volume 4.

Effects of Urban Runoff on Groundwater Quality

The movement of pollutants in urban runoff is a concern. Urban runoff contains chemical constituents and pathogenic indicator organisms that could impair water quality. Studies by the EPA (U.S. Environmental Protection Agency 1983) and the U.S. Geological Survey (Schroeder 1993) indicate that all monitored pollutants stayed within the top 16 centimeters of the soil in the recharge basins. The actual threat to groundwater quality from recharging urban runoff depends on several factors, including soil type, source control, pretreatment, solubility of pollutants, maintenance of recharge basins, current and past land use, depth to groundwater, and the method of infiltration used.

Nuisance Problems/Other Concerns

The presence of standing water in recharge basins and other drainage and storage structures can lead to vector problems, such as mosquitoes and the transmission of West Nile virus. The California Department of Public Health has developed guidelines that address the issue of vector control in basins. These same concerns also apply to the on-site capture of runoff for later use.

A number of state agencies are encouraging infiltration and have found it to be an effective means of dealing with surface water pollution and the excess volumes and velocities of runoff created in the urban environment. However, it is also acknowledged that infiltration is not appropriate in all circumstances. Examples of this would be the widespread use of infiltration in a brownfield development or infiltrating large amounts of water in hillside developments where slope stability may be an issue.

Protecting Recharge Areas

Local land use plans often do not recognize and protect groundwater recharge and discharge areas. Areas with soil and geologic conditions that allow groundwater recharge should be protected where appropriate. If development does occur in these areas, the amount of impervious cover should be minimized, and infiltration of stormwater should be encouraged on both a regional scale as well as at the "lot" level. In 2010, the Los Angeles and San Gabriel Rivers Watershed Council (now known as the Council for Watershed Health) prepared a water augmentation study that looked at the results of stormwater infiltration and the impact on groundwater (Los Angeles and San Gabriel Rivers Watershed Council 2010). Refer to Volume 3, Chapter 25, "Recharge Area Protection," for additional information.

Misperceptions

There are many misperceptions about urban runoff and its management. Urbanization changes the native landscape and creates many sources of urban runoff pollution. Urbanization brings about increases in impervious surfaces that do not allow precipitation to infiltrate into the ground, causing increased runoff volume and velocity that changes streams to become more "flashy." In addition, the traditional way that the urban environment has been landscaped (lawns) has called for the use of lawn care products to keep lawns green and free from weeds and other unwanted vegetation. The use of lawn care products creates a pollutant source when excess watering washes products off and into the storm sewer system. Likewise, the transportation system creates sources of runoff pollution.

Storm sewer systems have been designed to carry water away from the urban environment in order to reduce localized flooding during storm events. The systems have worked well in this regard, which has led to the public often times viewing runoff as a waste. However, with increasing demands on a limited water supply (surface water and groundwater) and climate-induced changes in precipitation patterns, water that otherwise would run off and be discharged to surface waters is being viewed as a resource. Changes in how new developments are planned and built, and changes in how we manage the existing urbanized areas, can create opportunities to capture runoff for future use.

Existing Codes

There are current codes and ordinances within State and local government that could conflict with some of the goals of managing urban runoff. Dry-weather flows have been shown to be significant sources of pollution, with one of the primary dry-weather flows being runoff associated with landscape irrigation and lawn watering. Reduction/elimination of these flows not only provides a water quality benefit, but also reduces the amount of potable water that is being used in a community. However, some municipalities have “green lawn” ordinances, and compliance oftentimes leads to runoff. Other codes require minimum street widths that can inhibit the minimization of impervious surfaces.

Recommendations

State

State agencies should:

1. Coordinate their efforts to decide how urban stormwater runoff management should be integrated into their work plans.
2. Coordinate their efforts to develop a single message to the public and local government regarding managing urban runoff through the use of low-impact development (LID) techniques.
3. Coordinate their efforts to develop appropriate site design requirements that can be incorporated into either local building codes or statewide building standards.
4. Lead by example by incorporating LID into projects to showcase the use, utility, and cost of the features. Site design should be given the same attention that indoor environmental quality, energy usage, etc., are given in the design, funding, and construction of public projects.
5. Encourage public outreach and education about the benefits and concerns related to funding and implementation of urban runoff measures.
6. Provide leadership in the integration of water management activities by assisting, guiding, and modeling watershed and urban runoff projects.
7. Work with local government agencies to evaluate and develop ways to improve existing codes and ordinances that currently stand as barriers to implementing and funding urban stormwater runoff management.
8. Provide funding and develop legislation to: support development of urban runoff and watershed management plans; enable local agencies and organizations to pursue joint-venture, multipurpose projects; and collect information on regional urban stormwater runoff management efforts.
9. Assist agencies with developing recharge programs with appropriate measures to protect human health, the environment, and groundwater quality.
10. Work with federal policymakers and industry to create research and development incentives and to develop standards to reduce urban runoff from transportation-related sources, including lubricant systems, cooling systems, brake systems, tires, and coatings.

11. Maintain a publicly accessible clearinghouse of information regarding practices that can be used to address water quality issues associated with urban stormwater runoff management.
12. Work with local government to seek legislative solutions to the limitations imposed by Proposition 218.

Local Agencies and Governments

Local agencies and governments should:

13. Design recharge basins to minimize physical, chemical, or biological clogging; periodically excavate recharge basins when needed to maintain infiltration capacity; develop a groundwater management plan with objectives for protecting both the available quantity and quality of groundwater; and cooperate with vector control agencies to ensure the proper mosquito control mechanisms and maintenance practices are being followed.
14. Seek opportunities to include LID techniques in public works projects.
15. Work with the development community to identify opportunities to address urban stormwater runoff management, including LID, in development and redevelopment projects.
16. Develop urban stormwater runoff management plans, integrating the following practices into the development process:
 - A. Understand how land use affects urban runoff.
 - B. Communicate with other municipalities regarding how land use will change the hydrologic regime on a regional basis and how this change is being addressed.
 - C. Look for opportunities to require features that conserve, clean up, and reduce urban runoff in new development and in more established areas when redevelopment is proposed.
 - D. Be aware of technological advances in products and programs through communications with other municipalities, branches of local government, and professional organizations.
 - E. Learn about urban runoff and watershed ordinances already in place. For example, the City of Santa Monica and the Fresno Metropolitan Flood Control District already have extensive urban stormwater runoff management programs in place.
 - F. Integrate urban stormwater runoff management with other resource management strategies covered in this volume, including pollution prevention, land use planning and management, watershed management, urban water use efficiency, municipal recycled water, recharge area protection, and conjunctive management and coordinate both within and across municipal boundaries.
 - G. Be sensitive to the fact there are going to be sites where it is not appropriate to infiltrate urban runoff and stormwater flows.
 - H. Integrate urban stormwater runoff management with development goals and strategies in the community.
17. Communicate with citizens about pollution of urban runoff and what can be done about it.
18. Create lists of locally accepted practices that could be used at the homeowner level to address urban runoff.
19. Review codes and ordinances to determine whether there are impediments to managing urban runoff and amend these as needed or as is appropriate.
20. Coordinate urban stormwater runoff management with local water purveyors to ensure the goals and activities of each complement each other rather than conflict.
21. Seek opportunities to provide incentives for the installation of LID features at the lot level for new and existing developments.

Urban Stormwater Runoff Management in the Water Plan

[This is a new heading for Update 2013. If necessary, this section will discuss the ways the resource management strategy is treated in this chapter, in the regional reports, and in the sustainability indicators. If the three mentions aren't consistent, the reason for the conflict will be discussed (e.g., the regional reports are emphasizing a different aspect of the strategy). If the three mentions are consistent with each other (or if the strategy isn't discussed in the rest of Update 2013), there is no need for this section to appear.]

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Box 20-1 Objectives of Urban Stormwater Runoff Management

- Protection and restoration of surface waters by minimizing pollutant loadings and negative impacts resulting from urbanization.
- Protection of environmental quality and social well-being.
- Protection of natural resources (e.g., wetlands and other important aquatic and terrestrial ecosystems).
- Minimization of soil erosion and sedimentation problems.
- Maintenance of predevelopment hydrologic conditions.
- Protection and augmentation of groundwater supplies.
- Control and management of runoff to reduce or prevent flooding.
- Management of aquatic and riparian resources for active and passive pollution control.

Box 20-2 Elmer Avenue Neighborhood Retrofit Demonstration Project

The Elmer Avenue Neighborhood Retrofit Demonstration Project is part of the Los Angeles Basin Water Augmentation Study, led by the Council for Watershed Health (formerly the Los Angeles and San Gabriel Rivers Watershed Council) and including multiple stakeholders. The project was designed to capture and infiltrate the runoff generated by a 0.75-inch design storm within the 40-acre residential catchment that fed surface flow to the 5800 block of Elmer Avenue. This block is a residential area with 24 single-family homes, located in the San Fernando Valley, that was susceptible to floods due to the absence of storm drains and sidewalks. The project improves drainage and groundwater recharge and provides stormwater quality mitigation through the application of multiple low-impact development strategies on both public and private lands (Los Angeles and San Gabriel Rivers Watershed Council 2010).

A wide range of integrated management strategies and practices are part of the demonstration, from individual rain barrels (cisterns) on single-family homes to wide-scale infiltration trenches that were constructed underground along roadways. All of the systems are a focus of an extensive monitoring program under way that provides knowledge about the physical and social effectiveness of the installed systems.

The project was designed to provide 16 acre-feet (af) of groundwater recharge annually. Measurements and estimates suggest that in 2010-2012 the systems infiltrated about 40 af over the two years, exceeding the groundwater recharge design goal. Two large infiltration systems are under the roadway and handle the bulk of the recharge. Bio-swales are used to capture flow from the residential parcels. The project included retrofits to individual homes, with features such as porous pavement, rain barrels, native planting, and rain gardens.

PLACEHOLDER Photo A Elmer Avenue Infiltration Galleries Before They Were Buried under the Street

[Any draft photos available for the public review draft appear after this box.]

PLACEHOLDER Photo B Depressed Swale Mini-Creek Bed Center, Complete with Drought-Resistant Native Landscaping (sidewalk left, curb right)

[Any draft photos available for the public review draft appear after this box.]

PLACEHOLDER Photo C Elmer Avenue Curbside Bio-Swale Filled by Half-Inch Rainstorm

[Any draft photos available for the public review draft appear after this box.]

Photo A Elmer Avenue Infiltration Galleries Before They Were Buried under the Street

[photo to come]

**Photo B Depressed Swale Mini-Creek Bed Center, Complete with Drought-Resistant Native Landscaping
(sidewalk left, curb right)**

[photo to come]

Photo C Elmer Avenue Curbside Bio-Swale Filled by Half-Inch Rainstorm

[photo to come]

Box 20-3 Stormwater Cistern, Coldwater Canyon Park, Los Angeles

In an effort to reduce demand for imported water supplies and cost, the nonprofit organization TreePeople designed and constructed a 216,000-gallon cistern, underground stormwater storage tank, in Coldwater Canyon Park in Los Angeles. This innovative runoff management strategy captures and stores stormwater runoff to use on-site for irrigation during the dry months. The installation includes a stormwater storage and collection system to capture stormwater that falls on nearby building rooftops and a parking lot. Stormwater that falls onto the parking lot flows into a centralized gravel trench drain, which filters it. The water then seeps into pipes and is carried to the cistern. The buildings are also fitted with rain barrels in order to provide additional storage for rainwater. These barrels can be used to water urban watershed gardens that help allow for more infiltration of water on-site (TreePeople 2012b).

In 2010, the TreePeople facility captured more than 70,000 gallons from a three-day Los Angeles storm. A TreePeople Web page (TreePeople 2012a) states, "This solution prevents local flooding, helps keep beaches clean and if implemented widely, could stimulate the economy. ... Last year, despite the declared drought emergency, TreePeople's cistern captured enough rainwater to meet most of Coldwater Canyon Park's irrigation needs, greatly minimizing the nonprofit's dependency on the L.A. City water grid."

PLACEHOLDER Photo A TreePeople's 216,000-Gallon Cistern Under Construction

[Any draft figures or photos that accompany this text for the public review draft will follow this box.]

PLACEHOLDER Photo B TreePeople's Parking Lot with Storm Drains Piped to Cistern

[Any draft figures or photos that accompany this text for the public review draft will follow this box.]

Photo A TreePeople's 216,000-Gallon Cistern Under Construction

[photo to come]

Photo B TreePeople's Parking Lot with Storm Drains Piped to Cistern

[photo to come]

Box 20-4 Examples of Pollution in the Urban Environment

- Herbicides and pesticides from landscaped areas (residential and commercial), golf courses, city parks, etc.
- Oil, grease, and heavy metals from normal vehicle use (automobiles, trucks, and buses) that accumulate on streets, roads, highways, driveways, and parking lots (leaks and drips, brake pad dust, tire wear, etc.).
- Sediment from improperly managed construction activities.
- Litter and green waste.
- Bacteria from improperly maintained septic systems, encampments, and waste from pets and wildlife.
- Nutrients from the application of excess fertilizers on landscaped areas (home, commercial, parks, etc.).
- Illegal dumping of material into the storm sewer system (used crankcase oil, antifreeze, pesticide container rinse water, etc.).
- Atmospheric deposition.
- Natural catastrophes.
- Building maintenance (pressure washing of lead-based paints, rinsing of walkways, etc.).
- Sanitary sewer overflows.
- Illegal cross connections with the sanitary sewer systems.

Box 20-5 Implementation Plan for Urban Stormwater Runoff Management Programs

Implementation of urban stormwater runoff management programs will require local agencies to:

- Promote coordination of interagency programs that protect water quality from urban runoff pollution.
- Reduce the potential for contamination of surface water and groundwater that results from uncontrolled or poorly controlled urban runoff practices.
- Develop tools to assess the effectiveness of urban water pollution programs.
- Increase the availability of regulatory and guidance documents and instructional workshops to demonstrate effective urban runoff pollution control programs and policies.
- Reduce the number of uncontrolled urban runoff pollution sources by increasing the number of municipalities, industries, and construction sites that use non-point source management measures and fit under the permitted State Storm Water Program.
- Develop and implement watershed-based plans, including total maximum daily loads and stormwater management programs in order to identify and address impacts from urban land use.

Box 20-6 Efforts to Quantify Benefits of Low-Impact Development

Low-impact development (LID) practices that emphasize infiltrating stormwater to recharge groundwater supplies or capturing rooftop runoff in rain barrels and cisterns for on-site use can be used to increase access to safe and reliable sources of water for end users, while reducing the amount of energy consumed and the greenhouse gas (GHG) emissions generated by supplying the water. Analysis by the Natural Resources Defense Council and University of California, Santa Barbara (2009) demonstrates that implementing LID practices at commercial and residential development and redevelopment, in urbanized Southern California and limited portions of the San Francisco Bay area, has the potential to increase water supplies by 229,000-405,000 acre-feet (af) per year by 2030. The water savings at these locations translate into electricity savings of 573,000-1,225,500 megawatt-hours (MWh), avoiding the release of 250,500-535,000 metric tons of carbon dioxide per year, as the increase in energy-efficient local water supply from LID results in a decrease in need to obtain water from energy-intensive imported sources of water, such as the State Water Project or energy-intensive processes such as ocean desalination.

The study analyzed geographic-information-system-based land use data, water supply patterns, and the energy consumption of water systems in California in order to estimate the water supply, energy use, and GHG emissions benefits of LID on a regional basis, under a conservative set of assumptions. The ranges presented for each benefit reflected a set of variables and input values used to create low and high estimates of potential savings. The study considered the percentage of impervious surface cover in the landscape; the density of development; the average annual rainfall; the soil type and infiltrative capacity; residential and commercial development rates; the energy intensity of current imported and local water supply sources; the effects of evapotranspiration; and local conditions, such as the presence of contamination or of shallow groundwater that may affect groundwater recharge.

Because the study included only a subset of urban areas within California, and incorporated only residential and commercial development, the true value of LID is likely higher than the results indicate. For example, expanding the use of LID to include industrial, government, public use, and transportation development in Southern California alone would have the potential to yield an additional 75,000 af of water savings per year by 2030, with corresponding reductions in energy use and carbon dioxide emissions. Finally, opportunities to implement LID practices that infiltrate or capture stormwater exist statewide. Even greater overall water supply, energy use, and GHG emissions reductions benefits would result from full application of LID and other green infrastructure techniques throughout all of California.

The Natural Resources Defense Council and University of California, Santa Barbara, research demonstrates that LID offers important opportunities to address vital issues of water quality and quantity, while simultaneously addressing climate change and its impacts on California. The results from this analysis suggest that LID is a worthy investment to meet many of the challenges faced by local agencies and communities.

